

Methods to Improve Collection, Storing, Re-cycling and Re-selling of Electronic Appliances In Central Finland

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<p>Abstract</p> <p>The purpose of the thesis was to find information about different kinds of methods for collecting, storing, re-cycling and re-selling that could be employed for the handling of electronic waste in Finland. Another purpose was to propose a possible business model for a new waste collecting company in Central Finland. The author analyzed the current processes of Finnish companies and their economic methods in order to improve electronic waste management. The current and possible future companies in this field need the present-day effective methods in order to classify data WEEE in working, repairable or non-useable appliances. All the proposals must also be based on cost effective and sensible logistics.</p> <p>For this purpose, theoretical information was used in order to build a strong foundation for this study. All the important laws and regulations that are in place in Finland were also studied and presented. Furthermore, the current processes and scenarios of electronic waste management companies were analyzed, and, based on those, various possibilities were mentioned which could be exploited in the future. The results were not only based on the current ways of working but also on the author's own ideas and plans. Numerous logistical solutions related to the collection, storing and re-selling of electronic appliances were given in order to complete the research task of the thesis.</p> <p>Based on the results of the study, present and future companies were advised to focus on the re-selling of electronic appliances since there is a great potential in this business. In addition to this, it was also suggested to concentrate on Central Finland because the number of electronic waste management companies did not match with the total number of population in this province. This shows that there is a definite void in this sector and that opportunities do exist for upcoming companies in this particular area.</p>		
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Abbreviations

WEEE	Waste Electrical and Electronic Equipment
EEE	Electrical and Electronic Equipment
E-waste	Electronic Waste
CRT	Cathode Ray Tube
PWBs	Printed Wiring Boards
LCD	Liquid Crystal Display

1 Introduction

1.1 Background

Waste is an enormous loss of material resources and energy in developed countries such as in the European Union. Therefore, the European Community has established its main objective to preserve, protect and improve the quality of the environment and human health, and the use of natural resources wisely. In addition, Community policy and action program on environment and sustainable development states that the achievement of sustainable development calls for significant changes in current development type, production, consumption and behavior. It also calls for the practices and pollution prevention sustainable consumption. To achieve these objectives and ambitions, the EU adopted a number of laws in order to contribute to the sustainable management of waste and use it as a key strength for a change.

Production and use of electrical and electronic equipment have increased significantly since the last three decades due to technological innovations and new applications of EEE. Rapid technological development has made EEE a part of everyday life that has led to rapid growth in waste electrical and electronic equipment. In order to solve the environmental problems related to the management and disposal of WEEE, and to ensure the functioning of the internal market, the European Community implemented the WEEE Directive in 2003. The main purpose of the WEEE directive is to encourage the producers to consider the design and manufacture of electrical and electronic equipment in relation to the life cycle management; an approach that takes into account their repair, possible upgrading, reuse, disassembly and recycling, and ultimately the best ways of recovery and disposal.

1.2 Objectives

The task in this thesis was to examine how Finland's waste management companies were collecting, storing, re-selling and recycling electronic appliances. The idea of this thesis was to give chance to new companies who are interested to work in Finland to access real life cases. The cases would be about those firms who were already involved in the E-waste management business. Furthermore, the results of this study would also explain how the management of Electronic waste can be done in an efficient and cost effective manner. The thesis would also highlight different rules and regulations that are in place,

moreover, what kind of methods are in use for handling the working, non-working and repairable electrical and electronic appliances. In addition, the proposals would focus on the different possibilities that exist in Central Finland for setting up a collection point.

2 Research Methodology

2.1 Methods in General

The research method used to carry out the study was case-study. A case-study is based on a qualitative approach. The reason for choosing the qualitative approach was that this study is explanatory. The primary purpose of this study was to provide with the opinions, motivations and understanding of the processes in order to gain an overall picture of the whole procedure. It does not contain any numerical analysis but it forms a hypothesis for future quantitative research. The sources for the qualitative data were the existing companies' process descriptions that were studied with the help of interviews, observations and a questionnaire. The theoretical basis was formed with the help of electronic sources, articles and books. Theory provides a strong foundation for this study without any interference with the investigation.

The thesis is divided into four parts. Firstly, there is a theoretical section that explains the principles related to the collection, storing and recycling procedures of WEEE. Secondly, a description of the current scenario of E-waste management in Finland is provided. Thirdly, different proposals are given for the present and future companies in order to collect and handle WEEE efficiently and cost-effectively. In the last section, a summary of the response to the research questions is provided and the reliability of the results has been evaluated.

2.2 Data Collection

Data collection was the most difficult part of the research process. As mentioned, data collection was done by using interviews, observations and a questionnaire. Three different types of interviews were conducted: by telephone, email and in-person interviews. The author contacted twenty organizations that were involved in the management of WEEE in Finland. Out of those twenty companies, only nine answered to the questionnaire. Three of

them were retailers, and the remaining were classified as official collection companies. During the data collection process, nine persons were interviewed. Six of the interviews were in-person, two were conducted via email and one was over the telephone. Some of those employees were field workers, and a certain percentage belonged to the top management. Furthermore, a great deal of travelling was required in order to collect the information. However, most of the company visits were not fruitful. The data collection process was complicated by the language barrier and the companies' attitude towards a student. The collection points were not willing to share their private information with an outsider, and therefore, it was extremely difficult to extract suitable data from the companies. The author contacted various companies operating in Central and other regions of Finland. Apart from the interviews, the author's own observations were also a primary source for data collection. The author went to different organizations in search of answers to the questions by observing the ongoing processes.

Furthermore, the preparation of the questionnaire was carried out in collaboration with the thesis mentor. The total number of the questions was sixteen. The questionnaire asked for explanatory replies, and it focused on the collection, storing and re-selling procedures. The questions were drafted in a proper document containing the contact details of the author and the thesis tutor. After the refining process, the document was sent as an email attachment to various companies. Moreover, in some cases, there was a need of translating the data from Finnish to English. In order to fulfill this requirement, assistance from thesis tutor had to be taken.

2.3 Data Analysis

This study falls into the category of qualitative research. The type of research is explanatory, since it is guided by the research questions. The data is analyzed in three steps: organizing the information, identifying a framework and using the framework for a descriptive analysis. The organization of data in this study was done by performing data cleaning and labeling. Labeling was done by structuring the information and familiarizing with it. Secondly, the framework was identified in the beginning of the study. It was clear from the start that this research has an explanatory framework. Since this thesis was not guided by the data, it could not be categorized as an exploratory study. The identification of the framework supported in structuring, labeling and defining the data. In the last step, a descriptive analysis of the collected data was performed. In the descriptive analysis, the

range of responses was classified in categories and recurrent themes were identified. The type of analysis used in this study was narrative. The analysis was based on interviews and observations, and therefore, the author had to sort, reflect, enhance and present them in a revised shape to the reader.

2.4 Research Questions

The following research questions were used in this study:

1. What are the processes happening at the collection points in Finland?
2. What are the responsibilities of the various entities involved in the reverse logistics of E-waste?
3. What kind of laws and regulations are in place?
4. Is there any possibility of setting up a collection point in Central Finland?
5. What are the estimated costs of running a collection point in Finland?
6. What kind of logistical problems are faced by the collection companies?
7. How to perform the collection and handling of WEEE in an efficient and cost effective manner?

3 Theoretical Basis

3.1 What is E-waste and WEEE?

E-waste includes all the electrical and electronic equipment that is dumped by the user without any desire of re-using them. This equipment includes: refrigerators, monitors, televisions, laptops, various kinds of lamps, washing machines, electric stoves, vacuum cleaners, microwaves, toasters and radios etc. All these wastes have different economic value and their recycling procedures also differ. E-waste is a serious environmental concern because it is not disposed of properly. Most of the waste either ends up in landfills or it is stored in the cabinets and drawers of the final user. (Balde, Wang, Kuehr & Huisman 2014, 12-13)

WEEE refers to Waste Electrical and Electronic Equipment. Discarded electrical and electronic equipment is WEEE. The electrical and electronic equipment cover all appliances that require an electric current, battery, or solar energy in order to operate. In

addition, all lamps, excluding incandescent and halogen lamps, are regarded as electrical and electronic equipment. The most common domestic electrical and electronic equipment include, among others, household appliances, clocks, computers, printers, mobile phones, televisions, consumer electronics, cameras, lamps, lights, and power tools.

Data WEEE covers electrical and electronic appliances containing a memory chip, such as computers, mobile phones, and digital cameras. These devices may contain the user's personal information, so it is recommended to leave them in a locked or sealed data WEEE collection container in the store that sells them.

3.2 Quantity of E-waste Worldwide

The quantity of E-waste generated worldwide in 2014 was 41.8 Mt. Out of 41.8 Mt, only 6.5 Mt of E-waste was treated properly. For most of the countries, the quantity of waste which is disposed of in the waste bins is unknown. Table 1 below describes this scenario. (Balde et al. 2014, 22-24)

Table 1 Global quantity of E-waste (Balde et al. 2014)

Year	E-waste generated (Mt)	Population (billion)
2010	33,8	6,8
2011	35,8	6,9
2012	37,8	6,9
2013	39,8	7,0
2014	41,8	7,1

Since this research is about Finland, it is important to present some stats related to it. The quantity of E-waste recycled and land filled in Finland can be found from table 2 below.

Table 2 E-waste treatment in Finland (Suomen virallinen tilasto)

Year	Recycled (1000t)	Land filled (1000t)
2006	29	11
2007	39	10
2008	45	7
2009	42	4
2010	45	4
2011	54	3
2012	120	0

3.3 Institutional Mechanism

3.3.1 Collection Systems

There are two types of collection systems found in every country: a “collective system” which is based on a monopoly and “clearing house system” which is based on competition. The aim for both systems is to provide economical WEEE management services for private users and businesses.

3.3.1.1 Collective System

The collective system is responsible for the collection and recycling of WEEE. It is mostly a non-governmental and not-for-profit system. This system divides the products into different categories in order to make the collection and recycling procedures more efficient.

3.3.1.2 Clearing House System

Unlike the collective system, the clearing house system is based on multiple partners. These partners include: producers, recycling companies and waste collection companies. There is a national body which is responsible for managing the producers so that they must fulfill their obligation of electronic waste management. Furthermore, this body also makes sure that WEEE is collected and recycled in an equitable manner throughout the country. (UNEP E-waste manual vol 2, 24)

3.3.2 Logistics

There are three logistical approaches for collecting WEEE, namely, the “municipal take back”, “retailer take back” and “producer take back.” The municipal collection channel is usually free for households. Private users can use it in an unlimited manner. The retailer take back is also free but in some cases, users have to buy a new product in order to dispose of the older one. The producer take back is limited in its nature. It is mostly used for large commercial equipment. This collection channel may also operate on the basis of exchanging a new product to the older one. (UNEP E-waste manual vol. 2, 25)

3.4 Collection Channels

3.4.1 Municipal Take Back

In the municipal take back collection method, private users and companies can leave the WEEE in the containers. The WEEE is mostly categorized and there are separate containers for each waste category. The sorting of waste can depend upon the logistical requirements related to the recycling and transportation of WEEE. This collection method is free for private users but enterprises may have to pay for it. (UNEP E-waste manual vol. 2, 38)

3.4.2 Retailer Take Back

In the retailer take back collection method, private households can leave their WEEE in the retail shops. The only condition is that these shops are selling similar kinds of products. In some cases, consumers have to buy a new product in order to give the older one back. This method is usually free for private consumers. (ibid., 38)

3.4.3 Producer Take Back

In the producer take back collection method, either the WEEE is taken back by the producers themselves at their premises. Alternatively, they arrange various collection points at different locations so that households and/or companies can drop their E-waste at those locations. (ibid., 38)

3.5 E-waste Treatment Technologies

There are three levels of E-waste treatment. All the levels focus on the material flow. The output of the first level acts as an input for the second level treatment. After the completion of the third level treatment, the slag goes for storage or disposal. The efficiency of the whole process is measured by the quantity of slag that is produced at the end. (MoEF 2008)

The overall outline of all these stages is presented in figure 1 below.

3.5.1 First Level Treatment

In the first level of treatment, the inputs include items such as televisions, refrigerators and personal computers and other similar appliances. There are three processes that occur at this stage of treatment, namely, removal of all liquids and gases, demolishing and separation. (ibid.,)

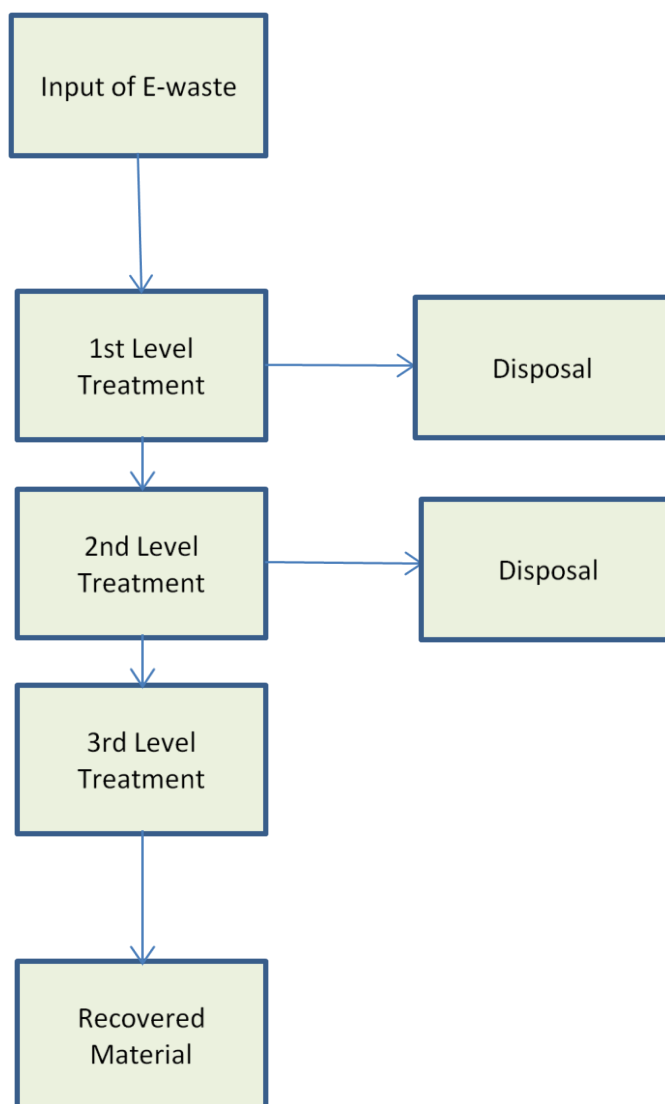
3.5.2 Second Level Treatment

In the second level treatment, the sanitized inputs from the first level are used. These inputs consist of separated non-hazardous materials such as plastics, CRT, circuit boards and cables. The processes that occur at this level include: hammering, shredding, CRT treatment (where the screen glass is segregated), electromagnetic separation, eddy current separation and density separation. The main processes at this stage are hammering and shredding. They are used for size reduction. (ibid.,)

3.5.3 Third Level Treatment

The third level treatment is mainly used to recover materials that have a market value. These materials include: ferrous- and non-ferrous metals as well as plastics. Separated and categorized plastic, ferrous metal scrap and non-ferrous metal scrap serve as inputs for this stage of treatment. Since this level consists of recovery, the main unit operation is recycling. (ibid.,)

Figure 1 Stages of Treatment (MoEF 2008)



3.6 Storing of E-Waste

E-waste must be protected from precipitation. Therefore, it must be stored in containers which are suitable for stopping water. Hazardous E-waste such as light bulbs, fluorescent lamps etc should be stored in closed containers and they must not be mixed with other waste. All the containers containing different kind of WEEE must be labeled properly. (MPCA,6)

Containers that are used for storing WEEE can be designed very efficiently in order to optimize the loading/ unloading and transportation related to E-waste. One possible solution is to use containers that have an open roof. This will make the packing and unpacking of the container very efficient since it is much easier to pack/unpack the container from the top. In addition, it will also allow the possibility of doing a partition within the container. (Gamberini, Gebennini & Rimini 2009, 2846-2858)

3.7 WEEE Recovery

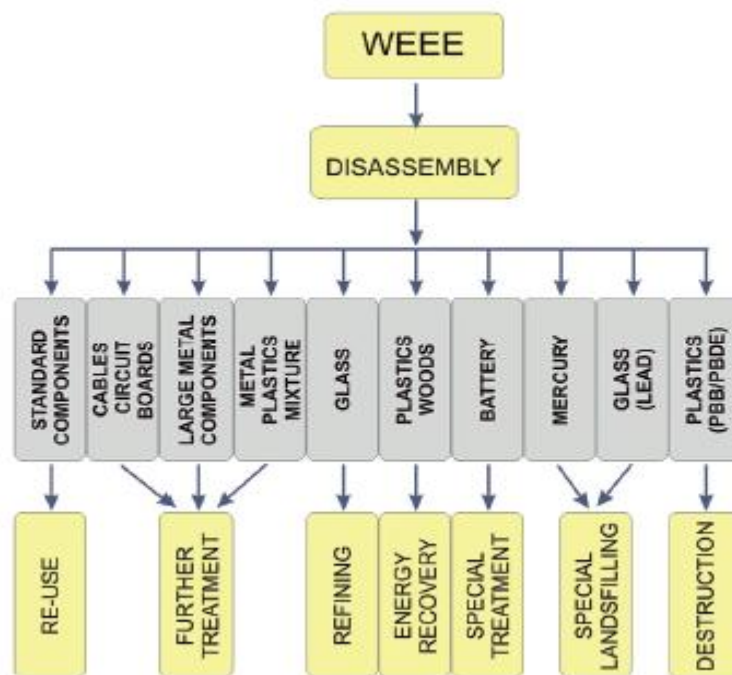
WEEE recovery is done before sending the components for recycling. The E-waste is first tested for whether it works or not. If it works, it has a re-use and re-sale value. If it does not work, the next step is to disassemble the WEEE. Disassembly is usually done by using hand tools. After the disassembly, some components such as memory chips and processors go through the testing procedure in order to identify any re-sale value. In the other cases, most of the materials are categorized into ferrous metals, non-ferrous metals, wires, plastics and PWBs. (Timothy 2011, 600)

The disassembly process can also be automated. Christoph and Sami (2015) presented various suggestions for automating the disassembly procedure in order to save high labour costs especially in the developed countries. Kopacek and Kopacek (1999) also highlighted the extreme potential of a fully automated demolishing process.

3.8 Recycling Procedures

Figure 2 describes the general recycling procedure of WEEE. Inbound WEEE is sorted into different product categories through disassembly and after that, it undergoes recycling.

Figure 2 Recycling Process (J.Cui 2003)



According to Antrekowitsch, Potesser, Spruzina & Prior (2006), there are mostly four procedures which are used for the recycling of electronic scrap i.e. mechanical separation, thermal treatment, hydrometallurgical treatment and electrochemical treatment.

3.8.1 Mechanical Separation

Antrekowitsch et al. (2006) state that in mechanical separation, firstly, different components are separated into metals, plastics, batteries, LCDs, capacitors and circuit boards etc. After this division, these substances are further treated. Plastics are disposed off since they contain high level of halogen content. Metals are treated by using metallurgical processes. It is very difficult to recycle circuit boards because there is a strong bond between metallic and non-metallic stages.

Materials can be separated magnetically, electro-statically or by using other techniques. Magnets can be used to separate ferrous metals. Williams (2006) argues that using permanent magnets instead of temporary magnets can reduce energy consumption. J.A. Stuart and Lu (2000) state that by passing the material several times through the magnets can increase the recovery of ferrous metals. After the recovery of ferrous metals, materials

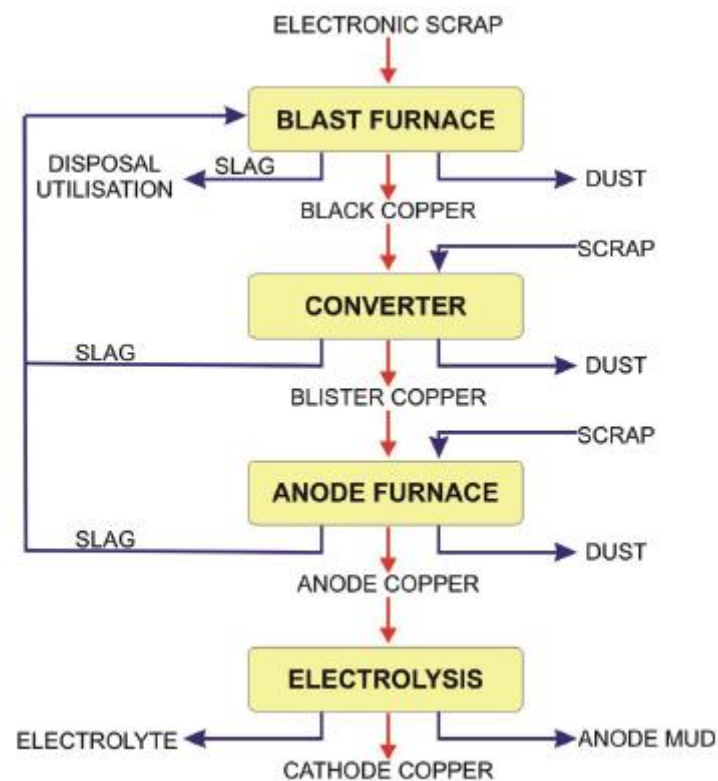
are forwarded for the removal of non-ferrous metals such as glass and plastics. This is done by eddy currents, electrostatics, air, float-sink or centrifugal force. (Williams 2006, 195-208)

3.8.2 Thermal Treatment

Thermal treatment includes various processes such as incineration, blending in a blast furnace, melting at a very high temperature and other similar processes (E.Y.L 1991). Removal of plastics is done by incineration where the scrap is burnt and melted. This will allow the extraction of metals from the molten electronic scarp leaving behind a slag of plastics. (Balart, Sanchez & Lopez 2006, 527-534)

There are many precious metals which are recovered from thermal treatment but in this example, show how copper is recovered from WEEE. Antrekowitsch et al. (2006) present the whole recovery process of copper. Firstly, the WEEE is put into a blast furnace where the blending is done. The output of this process is 'black copper.' After that, black copper is put into the convertor where it is converted into raw/blister copper. Raw copper contains small percentages of sulfur and oxygen. To remove these two substances, fire refining is done. This process is done by using an anode furnace. After achieving anode copper, it is further refined by electrolysis in order to produce pure copper. (See figure 3)

Figure 3 Recycling of WEEE containing copper (Antrekowitsch et al. 2006)



3.8.3 Hydrometallurgical Treatment

This process is used for increasing the quantity of metals by using acid or caustic leaching of a solid material. Solid material is put into the solvent, and metals are separated from the solution. H_2SO_4 , H_2O_2 , HNO_3 , HCL and NaOH are normally used as leaching solvents. (Antrekowitsch et al. 2006)

3.8.4 Electrochemical Treatment

This method is used for refining the metals. If some metal is coated onto the electronic scrap, it is dipped into an aqueous solution. By using electrolysis, the coated metal is recovered from the scrap. For example, gold and silver are recovered by using K/OH an aqueous solution. (E.Y.L 1991)

4 Case Study-Finland

4.1 WEEE Directive

In Finland, producer responsibility had already been launched in the late 1990s through the management of waste tires (Government Decree 1246/1995), packaging (962/1997) and paper (883/1998). However, in order to harmonize Finnish legislation with the requirements of the WEEE Directive, the Finnish Waste Act (1072/1993) had to be amended (452/2004) in June 2004 to include several new clauses on producer responsibility. In addition to the amendment of the Act, a Degree on Waste Electrical and Electronic Equipment (852/2004) was incorporated to the national legislation in September 2004.

According to the Finnish Waste Act 452/2004, producers of EEE were required to organize the re-use, recovery and other waste management of the products they had put on the market, and were responsible for the costs incurred. In addition, producers had to ensure that an extensive network of collection facilities was established in order to provide households with a reasonable opportunity to deliver their WEEE for recovery. Therefore, the importers and manufacturers have been responsible for organizing the transportation, collection, sorting, handling and recycling of WEEE all over Finland since August 2005. To fulfill this purpose, they have created producer organizations. All the importers and producers of EEE are required to become a member of either one or more than one producer organization. Producer organizations are responsible for steering contracts throughout Finland for the management of WEEE.

From the 1st May 2013, small household devices which are under 25 cm can be given to retailers without the obligation of buying a new product. Large household appliances can be delivered to shops by purchasing a new device in order to replace the old one.

The producer organizations should arrange an extensive collection system throughout the country so that, the end users will have an easy access to the collection points where they can leave un-wanted EEE. A private user can leave his/her EEE free of charge. However, non-private users such as enterprises are not allowed to drop WEEE in the collection points, and they are also charged.

Furthermore, there are separate laws for the collection and treatment of WEEE. It is strictly documented that WEEE must not be mixed with other waste. It should be collected and stored in such a way that those appliances that can be re-used are identified easily. During the recovery and treatment processes, all fluids must be removed from the appliances and all the processes must be done according to the European standards. (Government Decree 852/2004)

4.2 Producer Associations

In Finland, most electronic devices sold in the market are imported. Majority of the foreign and domestic manufacturers have transferred the responsibility of WEEE recovery to the producer associations. Currently, there are five producer associations providing services in the field of centralized management to fulfill the obligations related to practical matters set out in the WEEE Directive and to meet the relevant responsibilities mentioned under Finnish legislation. Three of these associations, Finnish Lamp Importers and Producers Association (FLIP ry), ICT Producer Co-operative (ICT-tuottajaosuuskunta) and Electrical and Electronic Equipment Producers' Association (SELT ry) have joined under an umbrella organization and service provider named Elker Ltd. in 2004. The Association of Electric and Electronic Equipment Manufacturers and Importers (SER-tuottajayhteisö ry, SERTY), established in 2000, and the European Recycling Platform Finland (ERP Finland ry), established in 2005 (initially named Nordic Electronics Recycling Association, NERA ry), operate independently. More than 500 producers joined the producers associations already in 2005 and, four years later, in 2009, more than 1000 companies had become members of these associations. The table below shows some of the stats related to producer organizations. (Toppila 2011)

Table 3 Producer associations stats (Toppila 2011)

Producer associations	Number of members	Market share (%)
SERTY	120	37
Elker group		29
SELT	673	
ICT	245	
FLIP	14	
ERP Finland	20	25

4.3 Present Situation

4.3.1 Tramel Recycling Process

Tramel Ltd was founded in 2008, environmental services and recycling industry operating company. The company operates, particularly metal-scrap and waste electrical and electronic equipment, as well as a collector extension handler.

The recycling process is as follows:

1. Firstly, TV screens will be separated from the CRT so that, the tube does not explode,
2. Secondly, electronic waste will be crushed,
3. Thirdly, plastic will be blown away,
4. Fourthly, crushed E-waste will be put into a pool of heavy liquid and as a result, the heaviest metal will fall down at the bottom of the pool,
5. Fifthly, crushed waste will be put into a pool of slightly lighter liquid and as a result, new metal will fall down at the bottom of the pool,
6. Finally, the lightest metal will be extracted from the last pool.

4.3.2 Role of SERTY

Serty is one of the five associations of importers and manufacturers of electric and electronic equipment in Finland. One of the employees of this organization named 'Ilona Kyto' was interviewed in order to get the overview of Serty. She told that all the importers and manufacturers pay a recycling fee to their producer organization. This fee is included in new equipment. With the help of this fee, producer organization is able to pay to the collection points.

Producer Organizations have organized nearly 450 collection points all over the Finland.

More information can be found at www.kierratys.info

Shops such as Gigantti, Prisma and K-city market etc. are also acting as collection points.

There are eleven companies who have recycling obligations in Finland. SERTY's recycling partners are Kuusakoski Oy, Tramel Oy, Rantasalmen Scel Oy, Stena Recycling, Cool Finland Oy, Suomen Elektroniikkakäsittely Oy and Elwira Oy. Kuusakoski and Stena

operate in Central Finland. Furthermore, SERTY uses companies such as DB Schenker and Jareks Oy for transportation purposes.

Although, it is possible to collect WEEE only with the permission of producer organizations, over 40 percent of WEEE disappears. Some of the equipment is at households but in most cases there are companies which take the equipment out of the country. As a result, the WEEE may end up in developing countries' electronic landfill.

Regarding the collection points, she told that every collection point has its own agreement with the producer organization. Some of the collection points only sort, some of them only collect and there are few collection points that fix broken equipment and re-sell it.

In response to a question about the possible opportunities which may exist in Central Finland for future companies, she said that there are few municipalities in this province that prevail without any collection point. Ilona told that there is no collection point in Toivakka and Muurame except some shops.

4.3.3 Description of Current Processes

Currently, there are 450 collection points in Finland which are organized by the producer organizations. Apart from the official collection points, WEEE is also collected in shops such as Prisma, K-city market, Gigantti, Expert and other retailers selling electronics.

Almost all the collection points do the preliminary sorting. They use open containers which are provided by the producer organizations. Those containers are labeled in order to categorize the WEEE. There are usually three to four different containers. There are separate containers for computers, televisions/monitors, refrigerators/electric stoves and other small appliances such as DVD players, vacuum cleaners and microwave ovens.

Most of the collection points do not separate working and non-working EEE. It is usually done at the recycling centers. Disassembly is also done by very few collection points and it is done manually.

The main aim in WEEE handling is to separate re-useable and non-useable appliances and spare parts. In the preliminary stage, those EEEs that have a re-useable value are

disassembled. Non-useable materials go to landfill, re-useable materials are sent to recycling companies and re-useable components are forwarded to second hand shops. (Lehtinen & Poikela 2006, 3)

Figure 4 Reverse Logistics of WEEE in Finland (Lehtinen & Poikela 2006)

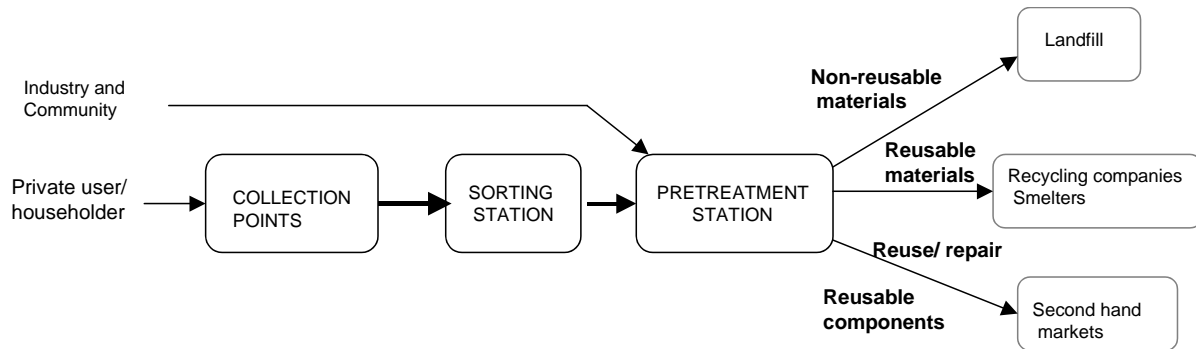


Figure 4 shows the reverse logistics of WEEE in Finland.

In the collection points, it usually takes from one to two weeks to fill up the containers depending upon the time of the year. In summers, the containers are filled up at a faster rate than in winters. The Christmas period, however, is the busiest in the year and loads of WEEE comes to the collection points.

Since private users can leave the electronic waste free of charge, the next question is how revenue is generated from this business. Basically, all the importers and manufacturers who put electronic products into the market pay a recycling fee to the producer organizations. Producer organizations pay to the collection points according to the total weight of the WEEE collected. No one is allowed to collect WEEE without the permission of producer organizations. In case of recycling companies, the situation is somewhat different. Instead of receiving money from the producer organizations for collecting E-waste, they have to pay them according to the total weight. The reason is that recycling companies are independent businesses whereas; collection points are not a separate entity. The collection points are a branch of producer organizations and they provide services for them in terms of WEEE collection. Therefore, the producers have to pay for them. Recycling companies are not meant to collect waste. Their job is to treat it and, therefore, the waste does not belong to them and that is why they have to pay for it in order to collect it. Recycling companies make money by selling metals recovered from the

scrap to different firms. At present there are eleven recycling companies operating in Finland.

There are recycling obligations for shops as well. If a consumer buys equipment, the shop must take the similar old equipment back. Smaller devices which are under 25 cm are collected in bigger shops such as Prisma, K-city market and Anttila, for example. All the waste from shops is collected by the recycling companies. The shops also do the preliminary sorting and they pay special attention to mobile phones which always go to a separate container. Some shops, such as Expert, also give some money to the consumer if the mobile phone is in a working condition. It takes almost three to four months for shops to fill up the containers. Gigantti is the only shop where the containers are filled up in a week.

4.4 Collection Possibilities in Finland

4.4.1 Mustankorkea Oy

Mustankorkea is an official collection point situated in Jyväskylä. It collects various kind of waste including WEEE. Piia Aho of Mustankorkea was interviewed in order to get a clear picture of the processes that are happening in this company. Mustankorkea is using three different containers for storing WEEE. These containers are dealing with electronic waste, small household appliances and refrigeration equipment. There is one more container that is meant for the storage of batteries and light bulbs. Mustankorkea is a member of Serty. Everything has been provided by the producer organization such as containers and transportation. Loimihämeen Jätehuolto Forssa (LHJ) is a company who is responsible for providing containers to Mustankorkea. It brings two containers and takes away one full container after every week. It takes one to two weeks to fill up the containers. Mustankorkea does not receive any waste from the retailers. This collection point is only utilized by private users. The company doesn't perform any disassembly. It also doesn't execute repairing and re-selling. All the sorting happens at the premises of its recycling partner. Tramel Oy is performing treatment obligations for Mustankorkea. Its truck comes once a week to take away the container to a small town named 'Nokia.' No collection point has the authority to choose a recycling partner itself. Producer organization will perform this task on behalf of every collection point.

Mustankorkea's employees also shared some logistical problems they are facing currently. Firstly, there is a problem related to sorting. Private users don't follow the sorting instructions written on the containers and as a result, they put the WEEE in wrong place. Secondly, there is a communication problem with the company who is responsible for bringing and removing the containers in their premises. In winter time, the amount of waste is very less, and therefore, LHJ has very few containers to transport. Due to this issue, it takes a lot more time to get this transportation service from LHJ. In summer time, the amount of waste is on a high level; therefore, LHJ is extremely busy in transporting the containers. Hence, in most cases it arrives late in Mustankorkea.

4.4.2 Vaentupa Oy

Vaentupa is a collection and re-selling point situated in Laukaa. It is the only hub in Central Finland that re-sells the electronic equipment. This interview gave healthy information about Vaentupa's operations.

Firstly, private users put the E-waste into the containers. There are three big containers and one small container. The big containers are dealing with TVs/DVD players, computer parts, washing machines/refrigerators and microwave ovens/vacuum cleaners. The smaller container is for storing light bulbs and fluorescent lamps. On average, it takes one week to fill up the containers. After the incoming E-waste goes to the respective containers, it is tested by the workers. Testing is done in order to identify the equipment that has a resale value. The appliances with a zero resale value goes for recycling. Any equipment that has a resale value goes to the second hand shop which is located inside Vaentupa's premises.

Vaentupa also does the repairing and demolishing of electronic appliances. Demolishing is done without using any machines. The workers break the equipment into smaller parts and sort them into different categories such as, plastics, metals, wires and computer parts etc. These materials are then sold to the recycling companies. Metals are sold to 'Reteko', plastics are sold to 'Kuusakoski' and aluminum, computer cards and wires are sold to 'Tramel.' Not all the goods are disassembled. Only computer parts and small televisions are demolished. No disassembly is performed on either bigger appliances or equipment that weighs less than 15 kilograms. The reason for demolishing the electronic appliances is to gain some extra amount of money from the recycling companies. Disassembling also

allows the re-selling of various materials. If a company wants to repair washing machines and electric stoves, the license of 'SP2' is essential.

Vaentupa also provides repairing services to private customers. It has separate testing, repairing and demolishing points. Furthermore, computers and televisions have independent testing and repairing facilities. To summarize, almost everything goes for recycling. Some of it is disassembled and repaired which is later on sold in either second hand shop or to the treatment facilities.

4.4.3 Kuusakoski Oy

Kuusakoski is a Finnish recycling company. It is operating on a large scale all over the Finland. It is treating different kind of waste including electronic waste as well.

Kuusakoski's operations differ from place to place. The following interview happened at the Kuusakoski's collection point in Jyvaskyla. The purpose of this interview was to investigate the situation of the collection points operating in Central Finland.

This Particular point is working only as a collection hub. Recycling is happening at Heinola. It is situated approx. 135 kilometers away from Jyvaskyla. WEEE comes from the stores, households and other collection points such as Mustankorkea and it is sent to Heinola. All the preliminary sorting and demolishing happens at the treatment plant. At this collection point, no sorting is done. Households can put the WEEE in any container. It takes one to two weeks to fill up the containers. In summers, E-waste is transferred to sorting station and recycling plant after every week. In winters, it takes a bit longer time for the containers to fill up. Since the WEEE is not sorted properly in this collection point, it usually causes fire in the containers due to short circuit. Waste such as batteries and florescent light bulbs cause the fire because they are not stored separately.

Kuusakoski doesn't repair and re-sell anything. Its only operation is to treat the E-waste. After the treatment, it sells the metals to different companies. This is the primary business of Kuusakoski.

Kuusakoski is a partner of Serty. All the WEEE that comes to the collection point is weighed so that a payment can be made to Serty. All the E-waste belongs to the producer

organizations. Due to this reason, recycling companies have to compensate their respective producer organizations in order for them to collect the WEEE.

4.4.4 Sammakkokangas Oy

Sammakkokangas is an official collection point located in Saarijarvi which is a part of Central Finland. The interview was done through email. It was a short interview and all the questions were answered briefly but it still gave a good idea about Sammakkokangas's operations.

Sammakkokangas has six waste stations and one waste management center. There is one container in each station. No sorting is done in the waste stations. All the containers are transported to the waste management center in Saarijarvi. The waste stations are located in Karstula, Kannonkoski, Kivijärvi, Kinnula, Pylkönmäki and Uurainen. In Saarijarvi, there are three WEEE containers and an open platform. Electric ovens and cookers, washing machines, dishwashers, microwave ovens and vacuum cleaners are sorted in open platform, whereas, TVs, computers and small electrical appliances such as hairdryers and razors etc. are sorted into three containers. The filling time of the containers depends on the time of the year. In summer, containers are filled more quickly as compared to winter. In summer, containers can be filled in a week's time, whereas, it can take up to two months for the containers to fill up in winter. In the waste management center, compact loader is used in the loading of containers but in the waste stations, loading is done by hands.

Sammakkokangas receives waste from households on behalf of the associations of electric and electronic equipment manufacturers and importers. Therefore, it sorts the electronic waste to WEEE containers according to the association to which the E-waste belongs. Sammakkokangas does not perform demolishing, repairing, testing and re-selling. Paivi told that they collect the electronic waste on behalf of the producer organizations and they are not allowed to hand over or sell electronic devices to any other entity than the operators of the producer organizations.

In response to a question about the possible costs related to these operations, she said that their company gets a payment per kilo received electronic equipment waste. Payments received on electronic equipment waste covers 80 % of the costs of operations.

She further told that very small percentage of workers is needed to handle the WEEE; hence, the labour cost is usually on a low level.

4.4.5 Lassila & Tikanoja

L&T was founded in 1905 in Vaasa. The company started as a wholesale business but soon developed its operations related to environmental management. L&T operates in Finland, Sweden and Russia. This interview was done with the business director of L&T and he gave very useful information about company's processes.

L&T mostly provides services to enterprises instead of households. Due to this reason, they don't perform any sorting. Teemu said that most of the scrap is useless and broken. Labour cost is very high, and therefore, there is no need to sort the waste. If a company is collecting E-waste from the enterprises, it doesn't have to make a contract with the producer organizations. The enterprises are usually not allowed to drop their E-waste in municipal collection points because of its huge volume. The municipal collection points cannot handle such a large amount of waste. They are only allowed to use official collection points if they have two or three similar appliances to drop. Due to these limitations, enterprises have to turn their attention toward companies such as L&T etc. Companies generate lots of E-waste annually and in order to transport it, they need big trucks. Concentrating on the transportation of WEEE will divert their attention from their main business. In order to avoid this diversion, they have to take services from L&T.

Apart from its enterprise business, L&T also have a contract with Serty in some of the municipalities. For example, in Joensuu, L&T has twenty collection points. These collection points belong to Serty and they operate exactly in the same manner as other official collection points are operating e.g. Mustankorkea. Unlike L&T's enterprise business, sorting is performed at these collection points. The separation is done using three containers. These three containers are dealing with cooling equipment, large domestic items and small electronic appliances. It takes three months for the containers to fill up in case of small collection points. Containers at the bigger collection points fill up in the span of one week to a month.

L&T doesn't do any re-selling, repairing and demolishing. The only focus is on the collection of WEEE. It has ten transfer stations in Finland and each station has approx.

eight to ten workers. L&T's recycling partners are Kuusakoski, Tramel, Stena, Cool Finland and Elvira.

Teemu also shared some of the logistical problems L&T is facing. In transfer logistics, it is facing space issues. He told that WEEE is very light but at the same time it consumes lot of space in the trailer. Due to this reason, it is very difficult to get enough weight for the truck. Second problem is related with the collection operations from clients. There are safety issues. Clients don't use appropriate containers, and therefore, L&T's truck driver has to do all the packaging by his own hands at client's premises.

4.4.6 Collection in Shops

The interview was taken from Expert, Gigantti and Prisma employees. Apart from official collection points, retailers also have an obligation for the collection of E-waste. Their methods of collection slightly differ from each other.

Not all the shops do the sorting. For example, Gigantti doesn't do any sorting, whereas, Expert does a bit of sorting. It separates batteries and mobile phones. The rest of the WEEE goes into the same container. In the case of Prisma, sorting is done more comprehensively as compared to other retailers. Prisma has separate containers for lamps, batteries, fluorescent light bulbs and electronic waste. Prisma only separates electrical equipment from electronic appliances but it doesn't perform any sort of categorization in E-waste. According to Prisma's employee, all the electronic appliances that go to the container are mostly non-working. He said that Prisma receives repairable electronic equipment that is under warranty. Testing is done in Prisma to decide whether it can be repaired or not. If it can be repaired, equipment is usually sent to the concerned company. If it can't be repaired, money is given back to the customer. Cheaper products are usually not sent for repairing; instead new ones are given to the customers. When the same question was asked from Expert, its employee said that they only separate working and non-working mobile phones. The rest of the E-waste is not identified in this manner. They have a green cardboard box for mobile phones. When customers return their mobile phones, they are tested on the spot. If they are in working condition, Expert gives back a small percentage of the price to the customer. Gigantti neither performs any sorting nor separation except the ones that are under warranty. No retailer does the disassembly of

the WEEE. Retailers do the testing in some special circumstances that are explained earlier.

In case of Prisma, it takes two to three months for the containers to fill up. In Expert, it can take up to one year since they mostly receive small devices. Gigantti seemed to be the busiest of all of them. It takes only a week's time for a container to fill up. Prisma's recycling partner is L&T. L&T doesn't do any recycling itself but its job is to transfer the waste to the concerned recycling company. Kuusakoski does the treatment for Gigantti. Expert's recycling partner is Stena.

4.4.7 Stormossen's Collection Lorry

Stormossen is a collection and treatment facility located in Vaasa. It collects E-waste from companies and households. It also has its own treatment facility that produces biogas from food waste.

Stormossen has a very unique method of collecting WEEE from households and other small companies. It has a collection lorry/truck that travels door to door for the collection of E-waste. It also goes to small nearby villages where people cannot access the collection points easily in order to drop their WEEE. This method will definitely improve the quantity of WEEE collected, because most of the collection points are inaccessible to households; therefore, lot of WEEE end up in nature. On the other hand, it can result in higher fuel costs for a collection point but negotiations can be made with the producer organizations by explaining the benefits that can be achieved by adopting such method of collection.

5 Results

5.1 Setting up a Collection Point

As discussed in the start of the thesis, the main aim was to locate the possibilities in Central Finland for setting up a collection point, and a few options do exist in Central Finland. One possibility is to set up a collection point which is solely dedicated to the collection of WEEE instead of repairing and re-selling. There is a definite room for a collection point in this region. According to research, there is no collection point in

Toivakka and Muurame. Muurame is an industrial municipality and industries have a great deal of E-waste to dispose of. Setting up a collection point will be a great help to this city. It was also discovered that over 40 percent of Finland's WEEE disappears. Therefore, a collection point in Central Finland can be a good business opportunity.

5.2 Setting up a Re-selling Point

Another possibility is to setup a collection plus re-selling point in Central Finland. There exists only one repairing and re-selling point in this province. It is operating in Laukaa. Furthermore, there is almost no competition in this business. Jyväskylä can be an ideal city for this kind of business since it is the largest city of Central Finland with an adequate amount of population. According to its population, this city needs some more collection points. Currently, there exists only one collection point apart from shops. Furthermore, this point does not do any re-selling. A re-selling point would also be a great help to the environment since it would minimize the disposal of electronic appliances to landfills.

5.3 Setting up a Treatment Facility

The next option is to establish a treatment plant in this province. There are a few drawbacks associated with this possibility. First of all, there is keen competition in this business. Companies, such as Kuusakoski and Stena are well established all over Finland. As mentioned earlier, there are eleven recycling companies operating in Finland, and their treatment facilities are widely spread including Central Finland. Hence, it could be very risky to invest in this business. Furthermore, the investment itself comprises substantial sums of money. Setting up a treatment facility equipped with the latest recycling technology is not at all cheap. Secondly, recycling companies have to arrange their own transportation, whereas, in the case of collection points, transportation is organized by the producer organizations. Thirdly, finding a buyer to purchase recovered metals is a hard task. Those eleven companies have stable contracts throughout Finland, and, therefore, there will be a tight room for a new company to establish its place as a supplier. Due to these risks, it is not advisable to indulge in this field of business.

5.4 Setting up a Collection Point Dedicated to Enterprises

The fourth option is also about setting up a collection point, but in this case it will serve enterprises instead of households. It is very hard for the enterprises to dispose of their

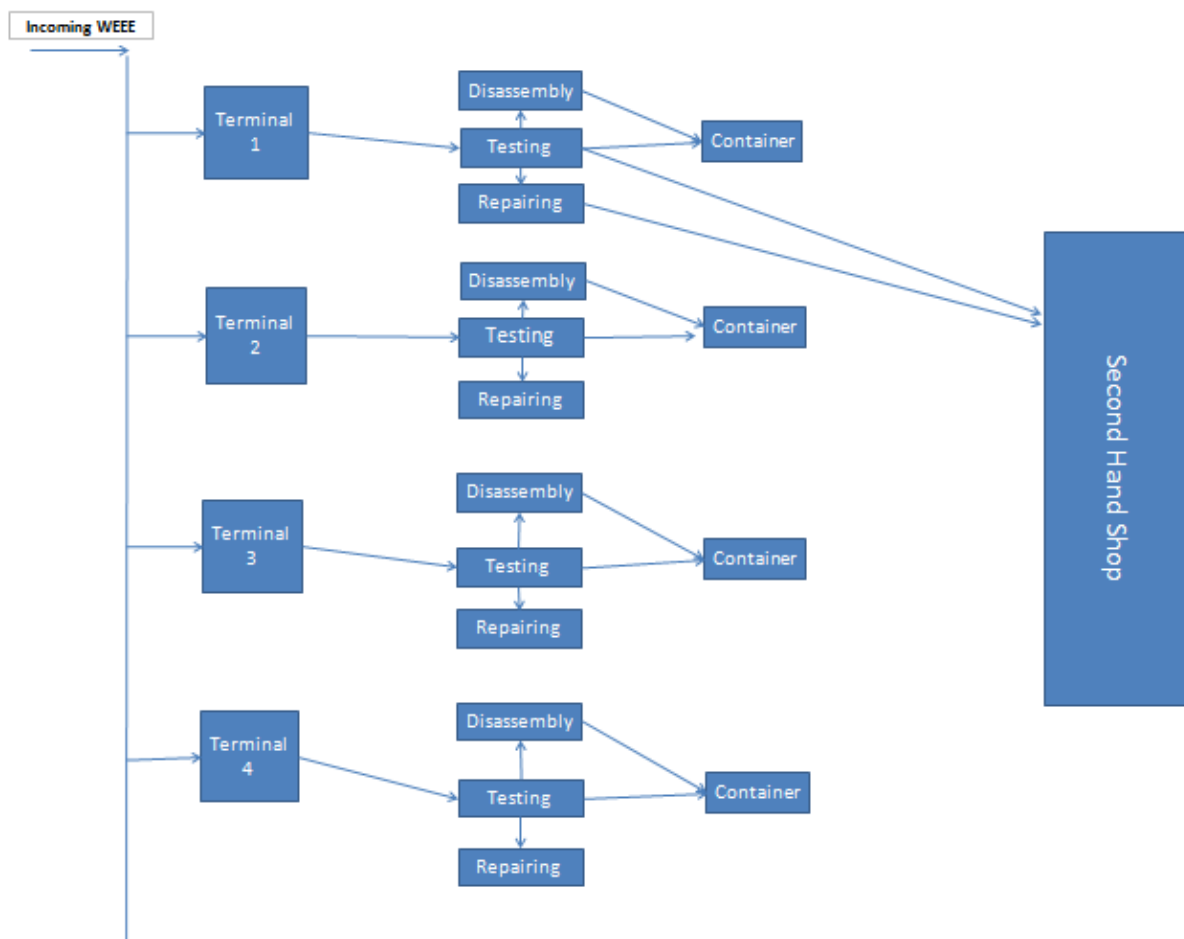
WEEE since most of the official collection points, which are meant for households, do not accept their E-waste because they do not have enough space for accumulating such large quantities of waste. This indicates that there is a good potential for building up a collection and re-selling point which is only dedicated to the enterprises. This nature of business does not require becoming a member of a producer organization because producer organizations in Finland are responsible for collecting the WEEE that comes from the households. Hence, this would be a completely independent business. Moreover, unlike the official collection points, transportation and containers have to be arranged by the company itself. However, this possibility is also not free from competition in which L&T (Lassila & Tikanoja) is a strong player. It is very stable in Central Finland and, in addition, it has a great deal of experience in the E-waste management business. The encouraging point is that there is only one strong competitor in this category, and therefore, the risk is not very high when compared to recycling business.

5.5 Proposals for Running a Re-selling Point

The below diagram represents a proposed layout and material flow plan of a collection point. This collection point would also act as a re-selling point. It performs six major tasks, such as collection, testing, disassembling, repairing, disposal and re-selling.

Firstly, the incoming WEEE will arrive at three or four different terminals. In the diagram below, four terminals are shown, but there can also be less than four terminals. The main aim of having different terminals is to categorize the E-waste. Another reason for having terminals is to prevent households from approaching the container area. The sorting of WEEE would not rely upon private users but, instead, it would be done by the terminal workers. Most of the time, private users do not follow the instructions and they put the E-waste in the wrong containers. Therefore, it is better if the WEEE is sorted by the collection point itself.

Figure 5 Layout and Material Flow



After the E-waste has been received by the terminal, it will undergo testing. Each terminal will have separate places for testing, disassembling and repairing. Testing will answer to four different questions: Which appliances are working? Which appliances are not working? Which of the appliances can be repaired? And which of the appliances can be disassembled? The working equipment will go to the second-hand shops. The non-working equipment will go to the disposal containers, demolishing section and repairing section.

Those electrical appliances that will go in the repairing area will eventually reach a second hand shop after they are repaired. In order to repair computers and laptops, it is very important to take care of the privacy issues related to the data. The data must be thoroughly destroyed by using efficient data destruction software.

The demolishing department will also deal with the non-working devices. The difference is that instead of repairing those, it will break them into smaller parts such as plastics, metals, wires and PWBs. After the demolishing, all these different parts will also arrive at the container area. In the above diagram, all the terminals have a demolishing facility, but it is not compulsory- because every non-working device cannot be disassembled. For example, there is no need to disassemble old-fashioned televisions and other small appliances because it is hard and time consuming and, hence, costly. Therefore, there is a possibility for a terminal of not having a demolishing facility. It will depend on the type of EEE received by a particular terminal. In most cases, it is wise to demolish the computers and laptops, since PWBs taken out of the computers can be sold at a good price to the recycling companies. The benefit of establishing a disassembling section is the opportunity to gain some extra income from the recycling firms (Appendix 5) that are always looking to outsource this duty to some other entity so that they do not have to do it themselves. However, there are only a few collection points that perform the disassembly.

The proposed collection point would need a maximum of five terminal workers. Three to four workers would do the testing and repairing, and one worker would be sufficient for performing the disassembly. There is no need for employing large workforce in the E-waste area, since the volume of WEEE is generally on a low level. Furthermore, very small quantity of WEEE has a re-sale value, and therefore, there is no need to repair large amount of appliances.

Another important issue that can be faced by a collection point is the stealing of WEEE. It is a very common problem in most of the collection points in Finland. The reason is the absence of defined boundaries and gates. Due to this reason, anyone can easily enter their premises at the night time. In order to avoid this issue, the proposed collection point would have a proper gate that can be locked after the end of working time.

5.6 Process Optimization

The main aim of providing with the above mentioned proposals is to make the collection point logistically efficient. In order to accomplish this goal, lean principles will act as an integral part of the collection point. The target of lean strategy is to minimize all kinds of wastes related to time, money and material. It focuses on increasing safety, optimizing the

space, decreasing movement and boosting the morale of the employees at the workplace. The main goal of the lean strategy is to provide with new ways of working in order to deliver benefits and value to the workers by organizing the human activities in an efficient manner.

In the above layout, material flow is planned in such a way that there will be no crossing between the materials and that there will be not back and forth movements. Both of these elements can increase the movements at the work area, and make the whole process very time consuming. Furthermore, a great deal of attention is given to sorting. What sorting does is that it separates the needed items from the unneeded ones. In this way, a great deal of space can be saved. The repairing and disassembling departments would be full of useless appliances that are meant for disposal if there would be no sorting.

The second most important principle to follow is 'setting in order.' This means a place for everything. For example, containers and tools must have a permanent point. Markings and instructions should be made so that the workers who are using the tools can return them back at their exact places. In this way, it will be far easier to find tools that are required at a particular time.

Thirdly, serious attention must be given to cleanliness. This means the cleaning of the area, machines and tools in order to make the workplace more pleasant. The most important factor is performing all these above mentioned duties on a regular basis. It is very essential to standardize these tasks by making them a regular practice at a collection point. By following these principles, substantial amounts of money and time can be saved and all the processes held efficient.

5.7 Responsibility Concerning Data Transfer and Removal

Nowadays, the issues related to data transfer and its removal is of great importance. Especially in Central Finland, whenever a consumer buys a new mobile phone, a laptop or a tablet, the data from his old device is not transferred to the new one. This can be a huge problem that stops the user from returning the old device to retailers. In order to solve this problem, the collection companies and retailers have to take responsibility of data transfer to encourage private users to drop their used devices to collection containers. Currently, most consumers prefer to keep their old mobile phones and other used electronics at

home. Secondly, existing collection points must also take initiative concerning data protection and privacy. They should completely remove and destroy the data from the old devices by using efficient data destruction software. This will establish some confidence among users concerning the return of WEEE. Any collection point that starts to provide such services must contact all those companies in Central Finland that sell electronic goods. In this way, these services can be expanded rapidly and moreover, the collection point will also increase its business opportunity throughout the province. Furthermore, the cost of providing these two services should be kept as low as possible in order to promote WEEE collection.

5.8 Collection Car Usage in Communes and Villages

As highlighted in section three, Stormossen Collection Company in Vaasa is employing an interesting idea of improving WEEE collection by using a small truck that travels in villages and in some companies in order to collect E-waste. This method of collection does not exist in Central Finland. The indicated method can prove extremely helpful, since, most of the collection points in Central Finland are not in range of every private user. Therefore, a collection car standing outside the premises of households will make it much easier for them to return their WEEE. Mustankorkea is one of the biggest official collection points in Central Finland. It can employ this idea in collaboration with Vaentupa that is a re-selling company in Laukaa. All the WEEE collected by the Mustankorkea's collection truck can be transported to Vaentupa in order to boost the re-selling of electronic appliances. This will also help in increasing the revenue of both the companies. Mustankorkea can earn money by providing collection services to Vaentupa. Furthermore, it will help Vaentupa to get more volume of E-waste, hence, increasing the opportunity of higher re-selling.

5.9 Promoting the Re-use of EEE

Despite the goal of the Finnish WEEE legislation to prevent waste generation and promote re-use, recycling and other forms of recovery of such waste, the current Finnish recovery system of WEEE does not promote the re-use of EEE. Above all, the re-use potential of the electronics is significantly underused in Finland, not only in the case of devices returned to the recovery system but also in cases when unused devices lay around in households storages. At this moment, it seems the information and guidance in collection points is inadequate in Finland. In order to enhance re-use, separate collection for re-usable equipment should be intensified and, in addition, testing system should be

established in connection with WEEE collection. Moreover, the market of re-used EEE needs to expand in Finland and also a change in consumer attitudes is required. It can be expected that raising consumer awareness will lead to environmentally sound behaviour and, ultimately, improve WEEE recovery efficiency.

5.10 Collection Campaigns

Collection campaigns can be another decent method for improving the volume of WEEE collected. These campaigns can be organized by University or high school students as part of different events. In these events, they can collect used mobile phones and tablets from private users and companies. However, one important aspect must be kept in consideration that if the aim of these student campaigns is to only collect the EEE, it must be done on the contract base. Permission must be taken from producer organizations' representatives, and all necessary aspects related to collection equipment and location must be taken into consideration. Required equipment will be provided by organizations' representatives for the collection. On the other hand, if the aim of the collection campaign is to promote re-sale and re-use of collected EEE, there is no need to notify the producer organizations. Finnish waste legislation allows the re-use of WEEE, although, the producer organizations discourage it due to conflict of interest. Hence, the EEE collected through these campaigns can be sold at a reasonable price by the students.

5.11 Rewarding Compensation to Households

In order to encourage private households to dispose off their WEEE, collection companies and second hand shops can reward small amount of compensation money for re-usable EEE. As mentioned earlier, some retailers such as, Expert, give small amount of money to users for returning mobile phones that are in working condition. This method can be applied to all the re-useable electronic appliances. Most of the private users keep the working EEE that is not in their use anymore inside the premises of their house. Therefore, a small amount of compensation can force them to realize their responsibility towards the recycling of WEEE.

5.12 Raising Public Awareness of Recycling

Greater public awareness of recycling can be achieved through a number of good practice measures such as provision of marketing materials, developing public engagement and

using front line staff to deliver the message. It will be easier to provide a consistent message if all the collection points in the area collect the same WEEE groups. Where this is not possible, campaigns should focus on a WEEE group that isn't well recognized. This can be identified by reviewing the type of WEEE that is collected. Independent collection points should also raise awareness of their services in order to maximize recycling at their sites. Awareness about recycling can be raised through marketing materials, for example, posters and radio adverts, secondly, promotion of the service online, in leaflets and brochures and in the local authority magazine, and thirdly, public engagement, for example, road shows or door-stepping.

6 Discussion

6.1 Response to Research Questions

The primary purpose of the data analysis was to answer the research questions posted in the beginning of this report. After reading the analysis part, it can be easily concluded that most of the collection points perform the sorting of WEEE. Few of them are involved in disassembling and re-selling operations. The separation of working and non-working EEE takes seldom place at the official collection points. Three important entities are involved in the reverse logistics of the WEEE- producer organizations, collection companies and recycling firms. Producer organizations represent the manufacturers and importers of EEE and they are in charge of all the operations related to the management of WEEE happening at the premises of the collection and recycling companies. No company is allowed to collect WEEE without the permission of the producer organizations.

Data analysis also helped in identifying various possibilities that exist in Central Finland for the management of WEEE. It was concluded that there were substantial opportunities for establishing a re-selling point in this region. The author also gave proposals in order to run this re-selling point in an efficient and effective manner. The proposals were based on 'lean principles.' Lean strategy will help in optimizing the costs of operations. Moreover, the author also gave various other methods for improving the collection and handling of WEEE in Central Finland.

Furthermore, during the analysis, it was estimated that a maximum of five field workers were needed for performing the collection operations. From this data, the amount of total labour costs may be estimated. On the other hand, the results of the data analysis did not give a concrete answer about the estimated total costs for running a re-selling point. The author did not have any access to the companies' documents and for this reason; it was impossible to estimate the total costs of running a WEEE collection company in Finland. The companies that cooperated with the author shared information about their daily processes at the collection points. These companies were also reluctant to share any information about the costs of the collection and storing processes. The argument they gave was that there is a tough competition in the field of electronic waste management. Hence, it was not possible for them to disclose the costs incurred in this business.

Another aim of this research was to find out the logistical problems faced by the collection points. According to author's observation, in spite of good WEEE recovery customs in Finland, some inefficient practices still exist, particularly at the registration and collection stages. The main challenges are related to the sizes of permanent collection points. In the smallest reception points, the physical spaces of collection cages are limited and the amounts of returned WEEE may vary substantially, causing careless handling and inappropriate storage conditions. Furthermore, the alarming situation lies in the fact that most of the companies were not able to identify any problems in their daily operations. Some of the problems that were shared with the author were related to theft, fire in the storage compartment and utilization of the truck space during the transportation of WEEE. The WEEE is very light but at the same time it consumes lot of space in the trailer. Due to this reason, it is very difficult to get enough weight for the truck.

6.2 Reliability of Results

The primary aim of this study was to produce results that could contribute to the efforts of the companies interested in the E-waste business in Finland. Therefore, it is also important to evaluate the reliability of the research results. The first part of the results of this thesis was designed with the help of practical cases. The results explain the tools and methods used for the management of E-waste. The results were adopted directly from the companies working in the field of the waste management business. However, the information was not taken from the companies' documents, and therefore, the results had

to rely on the words of the employees working in the E-waste management companies. The outcome of this study may erase confusions from the reader's mind about the current processes and procedures that are in use for WEEE management. Hence, the reliability of the tools and methods is on an acceptable level.

The second part of the results of this study was based on the proposals that were given for the efficient and effective management of WEEE. The proposals were based on the current ways of working and the author's own ideas. Since this part is dependent upon the author's plans and methods, a critical analysis of the reliability can be conducted on the second part of the research results. The author formed the proposals by establishing a solid base with proper reasoning, and, therefore, the probability of achieving a decent level of reliability is high.

The issue that can affect the reliability of the results in a negative way is the lack of real life cases related to the disassembling and reselling of electronic appliances. The study was able to found out only one company case involved in the demolishing and reselling of WEEE. The proposals related to this subject were made on the basis of only one example. If the proposals had been made after analyzing three to six different company cases, the reliability would have achieved a much better level in this particular section. The reason for the lack of cases was the availability factor- because only a few companies are involved in the reselling of WEEE in Finland. Furthermore, out of these companies, only one firm was willing to reply to the questionnaire. The other organizations did not pay any attention to the author's request. This factor resulted in achieving an insufficient sample size related to the reselling of E-waste.

7 Conclusion

This thesis focused on various methods that are necessary for the collection, storing, recycling and re-selling of electronic appliances. Most of the theory was presented in the start in order to give a literature perspective to different kinds of ways of managing E-waste. In the latter part, analysis and results of the case studies were given in order to establish a strong and more realistic foundation for WEEE handling.

Based on this study, it can be concluded that the implementation of the WEEE Directive and development of the WEEE recovery infrastructure has succeeded in Finland. At the same time as the legislative basis has been enacted, a functional infrastructure has been built successfully in a relatively short time. Nowadays, there are approximately 450 permanent WEEE reception points in more than 270 Finnish municipalities. In addition to the development of a functional nationwide collection network, the collection requirements of the Directive have clearly been exceeded and Finland has managed to achieve good recovery percentages in a few years. The real challenge of collection lies in ensuring that WEEE is collected separately that reusable equipment are separated from non-reusable ones, and both are sent to the adequate treatment facilities. It also needs to be pointed out that long distances in sparsely populated areas of Finland and the diversity of the WEEE brings special challenge to manage the reverse logistics of WEEE.

Although various collection channels are in existence, Finnish companies are using the 'producer take back' scheme for collecting E-waste. The producer organizations in Finland have formed a centralized network for the collection of WEEE. WEEE is not only collected by the official collection points but also by retailers who have the obligation to manage E-waste. In order to help the future companies, various possibilities were given for setting up a collection point in Central Finland. Furthermore, various methods were proposed in order to improve the collection and handling of WEEE. The Interviews gave a sound idea of the different kinds of processes that the companies were following. The suggestions were based on some of these processes plus the author's own ideas.

Hopefully, this thesis will prove beneficial for the upcoming and current companies interested in the E-waste business in Finland. The research gave a decent idea about the laws and regulations that are currently in place. In addition to this, it gave a wide view of the current situation of the companies involved in this business. Despite some limitations, the research also presented various possibilities that can be adopted in order to run such an enterprise.

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Appendices

Appendix 1. Operations of Serty

Date: 08.05.2015

Name: Ilona Kyto (Assistant)

Communication Medium: Email

Serty is one of the five associations of importers and manufacturers of electric and electronic equipment in Finland. One of the employees of this organization named 'Ilona Kyto' was interviewed in order to get the overview of Serty. She told that according to WEEE directive and Finnish legislation, the importers and manufacturers of household appliances are responsible for their waste management. Therefore, manufacturers and importers must organize the collection, transportation, sorting and recycling of electronic appliances in Finland. They had this obligation since August 2005. To fulfill this purpose, producer organizations have been formed and Serty is one of them. The other organizations are SELT, FLIP, ICT and European Recycling Platform. All the importers and manufacturers pay a recycling fee to their producer organization. This fee is included in new equipment. With the help of this fee, producer organization is able to pay to the collection points.

Producer Organizations have organized nearly 450 collection points all over the Finland.

More information can be found at www.kierratys.info

Shops such as Gigantti, Prisma and K-city market etc. are also acting as collection points.

There are eleven companies who have recycling obligations in Finland. SERTY's recycling partners are Kuusakoski Oy, Tramel Oy, Rantasalmen Scel Oy, Stena Recycling, Cool Finland Oy, Suomen Elektroniikkakäsittely Oy and Elwira Oy. Kuusakoski and Stena operate in Central Finland. Furthermore, SERTY uses companies such as DB Schenker and Jareks Oy for transportation purposes.

There are recycling obligations for shops too. For example, if a consumer buys equipment, the shop must take the old similar equipment back. Smaller devices which are under 25cm are collected in bigger shops such as Prisma, K-city market, Anttila and Ikea etc. Serty and other producer organizations must collect these devices too. From 1st May 2013, small

household devices which are under 25 cm can be given to retailers without the obligation of buying a new product.

Although, it is possible to collect WEEE only with the permission of producer organizations, over 40 percent of WEEE disappears. Some of the equipment is at households but in most cases there are companies which take the equipment out of the country. As a result, the WEEE may end up in developing countries' electronic landfills.

Regarding the collection points, she told that every collection point has its own agreement with the producer organization. Some of the collection points only sort, some of them only collect and there are few collection points that fix broken equipment and re-sell it.

In response to a question about the possible opportunities which may exist in Central Finland for future companies, she said that there are few municipalities in this province that prevail without any collection point. Ilona told that there is no collection point in Toivakka and Muurame except some shops.

Appendix 2. Operations of Kuusakoski

Date: 11.05.2015

Name: Riitta Peltosalmi (Operations manager)

Communication Medium: In person interview

Kuusakoski is a Finnish recycling company. It is operating on a large scale all over the Finland. It is treating different kind of waste including electronic waste as well.

Kuusakoski's operations differ from place to place. The following interview happened at the Kuusakoski's collection point in Jyvaskyla. The purpose of this interview was to investigate the situation of the collection points operating in Central Finland.

This Particular point is working only as a collection hub. Recycling is happening at Heinola. It is situated approx. 135 kilometers away from Jyvaskyla. WEEE comes from the stores, households and other collection points such as Mustankorkea and it is sent to Heinola. All the preliminary sorting and demolishing happens at the treatment plant. At this collection point, no sorting is done. Households can put the WEEE in any container. It takes one to two weeks to fill up the containers. In summers, E-waste is transferred to sorting station and recycling plant after every week. In winters, it takes a bit longer time for the containers to fill up. Since the WEEE is not sorted properly in this collection point, it usually causes fire in the containers due to short circuit. Waste such as batteries and florescent light bulbs cause the fire because they are not stored separately.

Kuusakoski doesn't repair and re-sell anything. Its only operation is to treat the E-waste. After the treatment, it sells the metals to different companies. This is the primary business of Kuusakoski.

Kuusakoski is a partner of Serty. All the WEEE that comes to the collection point is weighed so that a payment can be made to Serty. All the E-waste belongs to the producer organizations. Due to this reason, recycling companies have to compensate their respective producer organizations in order for them to collect the WEEE.

Appendix 3. Collection in Shops

Date: 19.05.2015

Name: Joonas Kakko & Ville Puura (Sales employee and materials handler)

Communication Medium: In person interview

The interview was taken from Expert, Gigantti and Prisma employees. Apart from official collection points, retailers also have an obligation for the collection of E-waste. Their methods of collection slightly differ from each other.

Not all the shops do the sorting. For example, Gigantti doesn't do any sorting, whereas, Expert does a bit of sorting. It separates batteries and mobile phones. The rest of the WEEE goes into the same container. In the case of Prisma, sorting is done more comprehensively as compared to other retailers. Prisma has separate containers for lamps, batteries, fluorescent light bulbs and electronic waste. Prisma only separates electrical equipment from electronic appliances but it doesn't perform any sort of categorization in E-waste. According to Prisma's employee, all the electronic appliances that go to the container are mostly non-working. He said that Prisma receives repairable electronic equipment that is under warranty. Testing is done in Prisma to decide whether it can be repaired or not. If it can be repaired, equipment is usually sent to the concerned company. If it can't be repaired, money is given back to the customer. Cheaper products are usually not sent for repairing; instead new ones are given to the customers. When the same question was asked from Expert, its employee said that they only separate working and non-working mobile phones. The rest of the E-waste is not identified in this manner. They have a green cardboard box for mobile phones. When customers return their mobile phones, they are tested on the spot. If they are in working condition, Expert gives back a small percentage of the price to the customer. Gigantti neither performs any sorting nor separation except the ones that are under warranty. No retailer does the disassembly of the WEEE. Retailers do the testing in some special circumstances that are explained earlier.

In case of Prisma, it takes two to three months for the containers to fill up. In Expert, it can take up to one year since they mostly receive small devices. Gigantti seemed to be the busiest of all of them. It takes only a week's time for a container to fill up. Prisma's recycling partner is L&T. L&T doesn't do any recycling itself but its job is to transfer the waste to the concerned recycling company. Kuusakoski does the treatment for Gigantti. Expert's recycling partner is Stena.

Appendix 4. Operations of Mustankorkea

Date: 12.05.2015

Name: Piia Aho (Environmental manager)

Communication Medium: In person interview

Mustankorkea is an official collection point situated in Jyväskylä. It collects various kind of waste including WEEE. Piia Aho of Mustankorkea was interviewed in order to get a clear picture of the processes that are happening in this company.

Mustankorkea is using three different containers for storing WEEE. These containers are dealing with electronic waste, small household appliances and refrigeration equipment. There is one more container that is meant for the storage of batteries and light bulbs. Mustankorkea is a member of Serty. Everything has been provided by the producer organization such as containers and transportation. Loimihämeen Jätehuolto Forssa (LHJ) is a company who is responsible for providing containers to Mustankorkea. It brings two containers and takes away one full container after every week. It takes one to two weeks to fill up the containers. Mustankorkea doesn't receive any waste from the retailers. This collection point is only utilized by private users. The company doesn't perform any disassembly. It also doesn't execute repairing and re-selling. All the sorting happens at the premises of its recycling partner. Tramel Oy is performing treatment obligations for Mustankorkea. Its truck comes once a week to take away the container to a small town named 'Nokia.' No collection point has the authority to choose a recycling partner itself. Producer organization will perform this task on behalf of every collection point. Mustankorkea's employees also shared some logistical problems they are facing currently. Firstly, there is a problem related to sorting. Private users don't follow the sorting instructions written on the containers and as a result, they put the WEEE in wrong place. Secondly, there is a communication problem with the company who is responsible for bringing and removing the containers in their premises. In winter time, the amount of waste is very less, and therefore, LHJ has very few containers to transport. Due to this issue, it takes a lot more time to get this transportation service from LHJ. In summer time, the amount of waste is on a high level; therefore, LHJ is extremely busy in transporting the containers. Hence, in most cases it arrives late in Mustankorkea.

Appendix 5. Operations of Vaentupa

Date: 19.05.2015

Name: Tuomo Makelainen (SER-vastaava)

Communication Medium: In person interview

Vaentupa is a collection and re-selling point situated in Laukaa. It is the only hub in Central Finland that re-sells the electronic equipment. This interview gave healthy information about Vaentupa's operations.

Firstly, private users put the E-waste into the containers. There are three big containers and one small container. The big containers are dealing with TVs/DVD players, computer parts, washing machines/refrigerators and microwave ovens/vacuum cleaners. The smaller container is for storing light bulbs and fluorescent lamps. On average, it takes one week to fill up the containers. After the incoming E-waste goes to the respective containers, it is tested by the workers. Testing is done in order to identify the equipment that has a resale value. The appliances with a zero resale value goes for recycling. Any equipment that has a resale value goes to the second hand shop which is located inside Vaentupa's premises.

Vaentupa also does the repairing and demolishing of electronic appliances. Demolishing is done without using any machines. The workers break the equipment into smaller parts and sort them into different categories such as, plastics, metals, wires and computer parts etc. These materials are then sold to the recycling companies. Metals are sold to 'Reteko', plastics are sold to 'Kuusakoski' and aluminum, computer cards and wires are sold to 'Tramel.' Not all the goods are disassembled. Only computer parts and small televisions are demolished. No disassembly is performed on either bigger appliances or equipment that weighs less than 15 kilograms. The reason for demolishing the electronic appliances is to gain some extra amount of money from the recycling companies. Disassembling also allows the re-selling of various materials. Tuomo also told that in order to repair washing machines and electric stoves, the license of 'SP2' is essential.

Vaentupa also provides repairing services to private customers. It has separate testing, repairing and demolishing points. Furthermore, computers and televisions have independent testing and repairing facilities. To summarize, almost everything goes for recycling. Some of it is disassembled and repaired which is later on sold in either second hand shop or to the treatment facilities.

Appendix 6. Operations of Lassila & Tikanoja

Date: 03.06.2015

Name: Teemu Salmela (Business director)

Communication Medium: Telephonic interview

L&T was founded in 1905 in Vaasa. The company started as a wholesale business but soon developed its operations related to environmental management. L&T operates in Finland, Sweden and Russia. This interview was done with the business director of L&T and he gave very useful information about company's processes.

L&T mostly provides services to enterprises instead of households. Due to this reason, they don't perform any sorting. Teemu said that most of the scrap is useless and broken. Labour cost is very high; therefore, there is no need to sort the waste. If a company is collecting E-waste from the enterprises, it doesn't have to make a contract with the producer organizations. The enterprises are usually not allowed to drop their E-waste in municipal collection points because of its huge volume. The municipal collection points cannot handle such a large amount of waste. They are only allowed to use official collection points if they have two or three similar appliances to drop. Due to these limitations, enterprises have to turn their attention toward companies such as L&T etc. Companies generate lots of E-waste annually and in order to transport it, they need big trucks. Concentrating on the transportation of WEEE will divert their attention from their main business. In order to avoid this diversion, they have to take services from L&T.

Apart from its enterprise business, L&T also have a contract with Serty in some of the municipalities. For example, in Joensuu, L&T has twenty collection points. These collection points belong to Serty and they operate exactly in the same manner as other official collection points are operating e.g. Mustankorkea. Unlike L&T's enterprise business, sorting is performed at these collection points. The separation is done using three containers. These three containers are dealing with cooling equipment, large domestic items and small electronic appliances. It takes three months for the containers to fill up in case of small collection points. Containers at the bigger collection points fill up in the span of one week to a month.

L&T doesn't do any re-selling, repairing and demolishing. The only focus is on the collection of WEEE. It has ten transfer stations in Finland and each station has approx.

eight to ten workers. L&T's recycling partners are Kuusakoski, Tramel, Stena, Cool Finland and Elvira.

Teemu also shared some of the logistical problems L&T is facing. In transfer logistics, it is facing space issues. He told that WEEE is very light but at the same time it consumes lot of space in the trailer. Due to this reason, it is very difficult to get enough weight for the truck. Second problem is related with the collection operations from clients. There are safety issues. Clients don't use appropriate containers, and therefore, L&T's truck driver has to do all the packaging by his own hands at client's premises.

Appendix 7. Operations of Sammakkokangas

Date: 05.06.2015

Name: Paivi Nieminen (Service manager)

Communication Medium: Email

Sammakkokangas is an official collection point located in Saarijarvi which is a part of Central Finland. The interview was done through email. It was a short interview and all the questions were answered briefly but it still gave a good idea about Sammakkokangas's operations.

Sammakkokangas has six waste stations and one waste management center. There is one container in each station. No sorting is done in the waste stations. All the containers are transported to the waste management center in Saarijarvi. The waste stations are located in Karstula, Kannonkoski, Kivijärvi, Kinnula, Pylkönmäki and Uurainen. In Saarijarvi, there are three WEEE containers and an open platform. Electric ovens and cookers, washing machines, dishwashers, microwave ovens and vacuum cleaners are sorted in open platform, whereas, TVs, computers and small electrical appliances such as hairdryers and razors etc. are sorted into three containers. The filling time of the containers depends on the time of the year. In summer, containers are filled more quickly as compared to winter. In summer, containers can be filled in a week's time, whereas, it can take up to two months for the containers to fill up in winter. In the waste management center, compact loader is used in the loading of containers but in the waste stations, loading is done by hands.

Sammakkokangas receives waste from households on behalf of the associations of electric and electronic equipment manufacturers and importers. Therefore, it sorts the electronic waste to WEEE containers according to the association to which the E-waste belongs. Sammakkokangas does not perform demolishing, repairing, testing and re-selling. Paivi told that they collect the electronic waste on behalf of the producer organizations and they are not allowed to hand over or sell electronic devices to any other entity than the operators of the producer organizations.

In response to a question about the possible costs related to these operations, she said that their company gets a payment per kilo received electronic equipment waste.

Payments received on electronic equipment waste covers 80 % of the costs of operations. She further told that very small percentage of workers is needed to handle the WEEE; hence, the labour cost is usually on a low level.

Appendix 8. Stormossen's Collection Lorry

Stormossen is a collection and treatment facility located in Vaasa. It collects E-waste from companies and households. It also has its own treatment facility that produces biogas from food waste.

Stormossen has a very unique method of collecting WEEE from households and other small companies. It has a collection lorry/truck that travels door to door for the collection of E-waste. It also goes to small nearby villages where people cannot access the collection points easily in order to drop their WEEE. This method will definitely improve the quantity of WEEE collected, because most of the collection points are inaccessible to households; therefore, lot of WEEE end up in nature. On the other hand, it can result in higher fuel costs for a collection point but negotiations can be made with the producer organizations by explaining the benefits that can be achieved by adopting such method of collection.

Appendix 9. Tramel Recycling Process

Date: 05.05.2015

Name: Pekka Janatuinen (Field employee)

Communication Medium: In person interview

Tramel Ltd was founded in 2008, environmental services and recycling industry operating company. The company operates, particularly metal-scrap and waste electrical and electronic equipment, as well as a collector extension handler.

The recycling process is as follows:

1. Firstly, TV screens will be separated from the CRT so that, the tube does not explode,
2. Secondly, electronic waste will be crushed,
3. Thirdly, plastic will be blown away,
4. Fourthly, crushed E-waste will be put into a pool of heavy liquid and as a result, the heaviest metal will fall down at the bottom of the pool,
5. Fifthly, crushed waste will be put into a pool of slightly lighter liquid and as a result, new metal will fall down at the bottom of the pool,
6. Finally, the lightest metal will be extracted from the last pool.

Appendix 10. Questionnaire

1. Does your company sort the electronic waste?
2. How do you separate working, repairable and non-working equipment?
3. What benefits do you get by demolishing the electronic appliances?
4. Do you demolish all kinds of electronic appliances?
5. Do you have separate places for testing, repairing and demolishing?
6. What is your demolishing method?
7. Do you repair and test electric and electronic devices?
8. Do you resell the working electronic or electrical devices?
9. Do you put electronic waste into the container?
10. If you use containers, how many of those you have? And what kind of electronic waste you put in each container?
11. If you use containers, how long does it take to fill up a container?
12. How often the transportation from your collection point to sorting station is done?
13. Do you use any loading equipment?
14. Who are your recycling partners?
15. How many persons are working in your company on the E-waste area?
16. Could the collection of electronic waste be more effective than now?

